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Stem Taper and Tree Growth Characteristics for *Triplochitonscleroxylon* (K. schum) Stands in Ibadan Metropolis, NIGERIA

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ABSTRACT:
Dearth of periodic and current information on forest tree stand has been greatly acknowledged in Nigeria. In 2010, a field study was carried out to assess the relationship between stem taper and tree growth parameters for *Triplochiton scleroxylon* (K. schum) stands in Ibadan metropolis, Nigeria. Stem taper is the changing diameter of a tree part over its length. Four age series (1973, 1974, 1975 and 1976) of *Triplochiton scleroxylon* trees were used for the study. Using stratified randomly sampling technique, temporary sample plots of size 20m by 20m randomly established in each of the age series and data collected on various tree dimensions included Diameter at breast height (Dbh), diameter at the base (Db), middle (Dm) and top of the trees (Dt), total and merchantable height and crown depth. Individual tree basal area and stem volumes were estimated using their respective empirical formula.. Two variants of stem taper, TAP^1 (defined as the ratio of tree diameter at the top to the diameter at the base) and TAP^2 (defined as the ratio of diameter at breast height to tree total height) were computed and tested against various tree attributes. The results showed that TAP^2 was significant while TAP^1 was not significant when tested across the different stand ages with 1976 stand having minimum mean value of 21.91 ± 5.98 and 1975 stands with maximum mean value of 28.70 ± 9.25. The result showed that the majority of the trees are of good taper, although the plot located within Forestry Research Institute of Nigeria arboretum showed a better taper form compare to those located within the reserves. However, it is recommended that permanent sample plots be established for regular and consistent data collection.

Keywords: Stem taper, *Triplochiton scleroxylon*, tree growth characteristics, Nigeria

INTRODUCTION

Tree growth follows many mechanical rules to assure survival. In order to prevent concentrating force at weak points, tree growth distributes loads and compensates for relatively weaker locations by adding more woody materials. One critical element of sustaining strength and stiffness is the amount of taper developed. Stem taper can be defined as the relative rate of change in stem diameter with increasing height; this change is a natural trend for the species and can be expressed using a mathematical function [1]. Within each portion of a tree, stem, branch or twig, taper rate changes. Taper is the degree to which a tree's stem or bole decreases in diameter as a function of height above ground, unlike slenderness coefficient which is the ratio of tree total height (THT) to diameter outside bark at 1.3m or 4.5ft above the ground level. Trees with a high degree of taper are said to have poor form, while those with low taper have good form. Taper varies with species, diameter at breast height and size [2]; also varies throughout age as a natural developmental phenomenon or results from phases of relative competition with neighboring trees [3] [4].

Recently, the study on stem taper is becoming significant in quantitative forestry following the susceptibility of many economic tree species to natural phenomenon such as wind damage, snap, blow down, breaking or uprooting of live tree as a result of high intensity of wind components. Many researchers have shown that taper is the principal factor affecting the susceptibility of a tree to wind damage [5] [6] [7].However, in Nigeria, the tropical rainforest ecosystem is a major source of timber supply to the wood industries [8]. The tropical rainforest ecosystem contain several indigenous tropical hardwood species of economic value which include *KhayaSpp, Triplochiton scleroxylon, Milicia excels* etc. [8]. The forest is renewable natural resources which require effective scientific management. The forest manager like any other resource manager requires reliable information of the current state of the standing timber in the forest in terms of its yield, growth, quality, quantity, size and location of the forest resources available and

how these resources are changing over time. This information leads to the knowledge about the growth and development of the forest stand which is considered important in forestry as it provides clues to the future behaviour and guide to the management of a given stand and also helps the manager in decision making about the forest stand. Figure 1 shows a *Triplochiton scleroxylon* trees in the arboretum.

According to research [9][7], the susceptibility of a stand to wind throw or damage is largely influenced by the taper of the tree and this vulnerability to wind most times is based on a combination of some tree growth characteristics, stand conditions, site soil and site quality, topography and wind patterns. These combinations generally substantiate the impact of both biological and physical factors on the individual tree or stand stability among exotic species [10] [11].Though several studies and results had been carried out and recorded on taper and stand stability potentials of tree plantations in many part of the world [12] [13]. The study on stem taper with reference to its relationship with the tree growth characteristics have not been adequately researched in Nigeria.

However, the current climate changes with series of environmental degradation and desert encroachment in the tropics including Nigeria necessitate critical assessment of the relationship between stem taper and Tree Growth Characteristics in Nigeria as it relates to evaluation of stand stability of *Triplochiton* spps in Nigeria. However, it was reported by [14] that little emphasis has been given to growth characteristics of many species in Nigeria and where silvicultural intervention had been adopted without good knowledge of growth characteristics, bad management decision are always made with attendance adverse effect on stand productivity. Therefore, this study explored the relationship between tree stem taper and tree growth characteristics for *T. scleroxylon* plantations in Gambari forest reserve and FRIN arboretum, Nigeria.

MATERIALS AND METHODS

Studyareas

Two sites were used for the collection of data on tree growth parameters of *Triplochiton scleroxylon* for this study. Gambari Forest reserve, located in the tropical dry semi-decidous lowland forest and Forestry Research Institute of Nigeria arboretum. Gambari Forest Reserve is situated along Ibadan-Ijebu Ode road in Oluyole Local Government Area of Oyo State on latitude 6˚50’N and longitude 4˚33’N. The reserve is located at about 152m above the sea level and of size 12,565ha [15]. Two distinct wet seasons occurring in the reserve, May to July and September to November. The average annual rainfall is about 1, 257mm while the relative humidity ranges from 84.5% in June to September and 78.8% in December to January [16]. The mean annual temperature is about 31.3˚C maximum and 21.0˚C minimum [16]. Forestry Research Institute of Nigeria is located on Longitude 3.51˚E and Latitude 7.23˚N, located along Aleshiloye-Jericho road in North West Local government area of Ibadan with mean annual rainfall of 2,035mm while average minimum temperature is 25°C [7]. Figure 3 shows the Gambari Forest Reserve.

Data Collection

Four age series stands of *Triplochiton scleroxylon* plantations were used (34, 35, 36 and 37years old). The 34, 35 and 36yrs old plantations were located within the Gambari Forest Reserve while the 37yrs old was located in Forestry Research Institute of Nigeria arboretum. A total of 24 temporary sample plots of size 20m by 20m were located and enumerated considering the sizes of the stands. Stratified Random Sampling Technique was used for carrying out this study. In each of the age series, 4 to 6 temporary sample plots were established and enumerated. Measurement taken and recorded included Diameter at breast height of all trees (cm), diameter at the base, middle and top of all trees (cm), crown depth and diameter of all trees, total and merchantable heights of all trees (m). Since an uneven aged stand may be defined as a stand containing groups of trees of varying ages with rather complicated development patterns, age and size distributions indicated that all study stands could be defined as uneven aged. The descriptive statistics of the measured parameters were provided in table 1 below.

Data Processing and Analysis

One way analysis of variance (CRD) was used to test for differences among the stand ages in terms of stem tapers. Product moment correlation analysis (Pearson Correlation Coefficient) was used to evaluate the association between the stem tapers computed and other tree growth characteristics. The data collected were processed into suitable form for statistical analysis as follows:

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Basal Area

The Basal Area for individual trees within each plot were estimated using;

Basal Area $=\pi D^2/4$ …………………..Eqtn 1

where, BA = Basal Area (m^2), π = 3.142 (constant), D = diameter at breast height (m).

Stem Volume

The Stem Volume of individual trees within each plot was estimated using the processed Newton's formula:

Stem Volume$=\pi h/24(D_b^2+4D_m^2+D_t^2)$……..Eqtn 2

where V= stem volume of individual tree (m^2), π = 3.142 (constant), h =Merchantable height (m), D_b= diameter at the base (m), D_m= diameter at the middle, D_t =diameter at the top (m)

Stem Taper Computation

Two variants of stem taper computed for evaluation in this study were:

StemTaper***(Tap¹)***$= D_t/D_b$ ……….Eqtn 3 and;

Stem Taper***(Tap²)***=DBH/THT ……..Eqtn 4

whereD_t =diameter at the top (m), D_b= diameter at the base (m), DBH= Diameter at breast height, THT = Total height of the tree.

Fig.1: A Triplochiton scleroxylon tree

Table 1. Descriptive statistics of measured tree DBH and Height for the *Triplochiton scleroxylon* stands

Age (years)	**N**	**DBH** (cm)			**Height** (m)		
		Mn	**SD**		**Mn**	**SD**	
37	59	(*13.27–36.70*)	24.97	6.40	(*5.00 – 29.80*)	20.66	5.63
36	65	(*11.30 - 39.88*)	22.54	6.89	(*3.80 – 28.70*)	17.26	6.09
35	52	(*11.30 – 50.95*)	28.70	9.25	(*6.80 – 57.50*)	18.80	7.48
34	80	(*10.95 – 38.10*)	21.91	5.98	(*3.80 – 30.80*)	17.79	5.88

N= number of trees with measured DBH and Height values; Mn= Mean; SD= Standard Deviation
Values in parentheses are the minimum and maximum of the variable

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Table 2: Results of Analysis of Variance (ANOVA) across the different stand ages

Sources of variation		df	Sum of Square	Mean of Square	F- ratio	Sig
Tap^2	Stand age	3	36.929	12.310	3.584	0.014*
	Error	252	865.477	3.434		
	Total	255	902.406			
Tap^1	Stand age	3	0.021	0.007	0.951	0.417ns
	Error	252	1.860	0.007		
	Total	255	1.881			

* Significant difference at P<0.05, ns: Not significant

Table 3: Correlation Coefficient between the Stem Taper and Tree Variables

Tree Variables	Tap^1	Tap^2
Age	0.30	0.43
Diameter at Breast height	0.020	0.130*
Tree height	-0.680	0.494
Crown diameter	-0.043	-0.030
Crown length	-0.34	-0.42
Basal Area	0.019	0.151*
Stem Volume	-0.214	-0.122

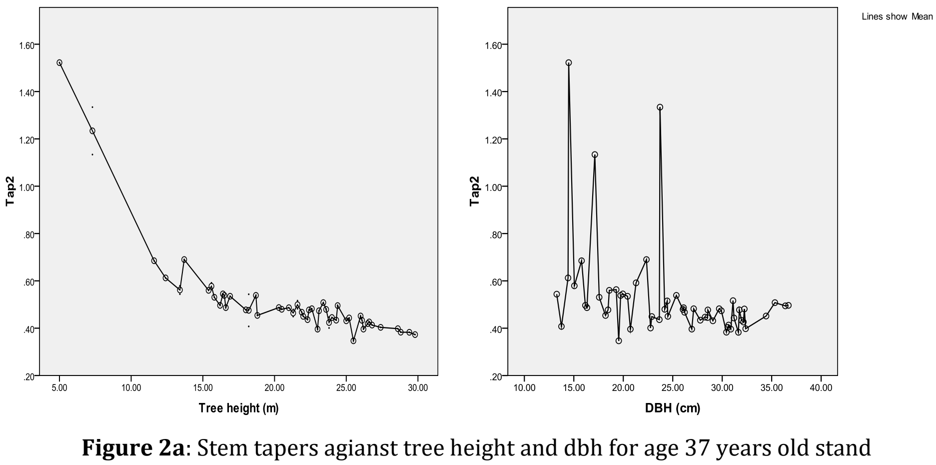

Figure 2a: Stem tapers agianst tree height and dbh for age 37 years old stand

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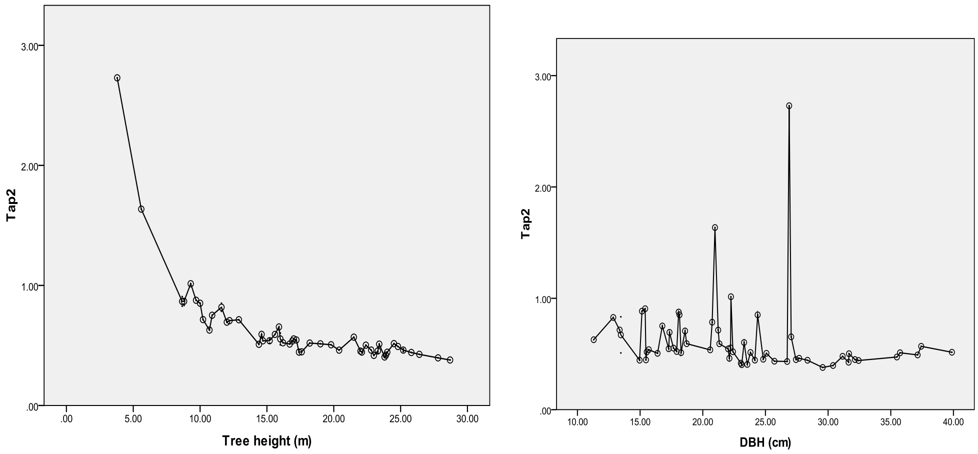

Figure 2b: Stem tapers agianst tree height and dbh for age 36 years old stand

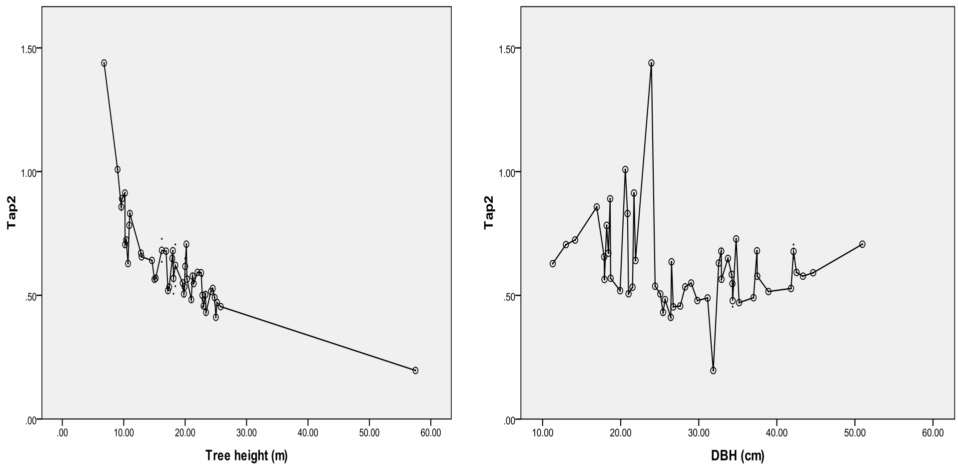

Figure 2c: Stem tapers agianst tree height and dbh for age 35 years old stand

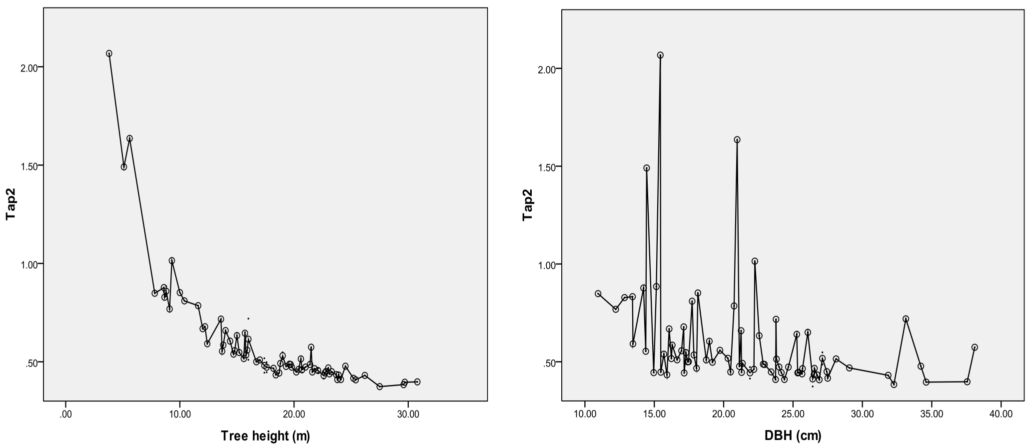

Figure 2d: Stem tapers agianst tree height and dbh for age 34 years old stand

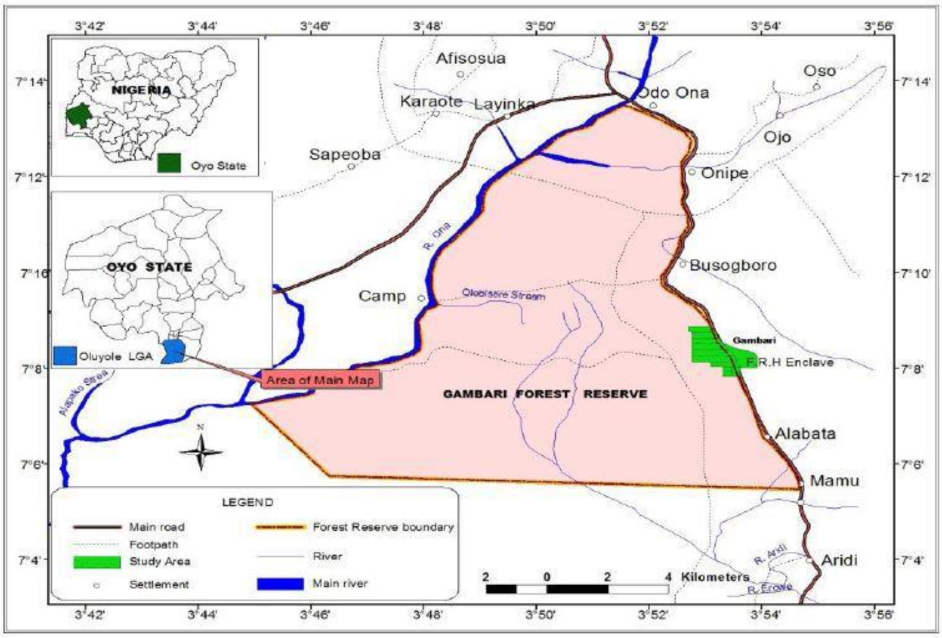

Figure 3: Map of Gambari Forest Reserve

RESULTS AND DISCUSSION

Results

The results of the ANOVA and correlation coefficient between the stem taper and tree variables were provided in table 2 and 3 respectively. Also, plots showing the relationship between the stem taper computed and the tree parameters (Height and Dbh) were provided in figure 2(a,b,c,d).

Discussion

The result of ANOVAabove shows that stem taper (tap^1) when assessed across the different stand ages was not significant (0.417) at the probability level of 0.05 while stem taper (tap^2) was found to be significant (0.014) at probability level of 0.05 (Table 2). Thus, tap^2 has a significant effect when assessed across the stand ages. That is, there are significant differences between the stand ages but the exact pairs of stand ages that are different were not known. However, the result of follow up test carried out (test of means) showed that stand age 37years with mean value (20.66) was significantly different from stand ages 36 and 34 years with mean values of 17.26 and 17.79 respectively while not significantly different from stand age 33years with mean value of 18.80 (table 1). Moreover, the difference observed in stand age 37years and other stand ages might be due to difference in location (site), plot composition (number of trees per plot) and different maintenance practices given to the stand.

However, the result of the correlation coefficient between the two stem tapers and tree diameter at breast height (DBH) was found to be positive and stem taper (tap^1) was found to be negative with the tree height while stem taper (tap^2) was found to be positive (Table 3). This result indicates that stem taper of *Triplochiton scleroxylon* stands studied tend to increase with increase in diameter; stem taper (tap^1) revealed a decrease as tree height increases while stem taper (tap^2) revealed an increase in stem taper as the tree height increases (Table 3). Also, the correlation coefficient between stem taper and tree height was higher than the correlation coefficient between stem taper and other tree attributes. This result was similar to result obtained by [17] which indicated that taper was negatively correlated with tree crown width for Norway spruce *Picea abies* (L.). This indicates that tree height is a better function that can be used in estimating stem taper for *Triplochiton scleroxylon*

stands studied than the tree diameter. This result was similar to the result obtained by [18].

Furthermore, crown depth, crown diameter and stem volume were found to be negatively correlated with stem taper while basal area was found to be positively correlated. The results confirm that stem taper values for the studied stands decreases with increasing crown depth and crown diameter.

CONCLUSSION

The relationship between stem taper and tree growth characteristics for *Triplochiton scleroxylon* have been established. Trees with a high degree of taper are said to have poor form, while those with low taper have good form. However, tree DBH and tree height are the two key predictors that determine the stem taper of *Triplochiton scleroxylon* species. For this study, the majority of the *Triplochiton scleroxylon* trees found in all the stands have a good form. However, the stands located at the Forestry Research Institute of Nigeria arboretum has a better form compare to those located in the reserves. This may be due to the adequate and proper forest management practices given to the stands in the research institute arboretum, difference in plot composition and also, in soil characteristics. The result of this study indicates that stem taper of *Triplochiton scleroxylon* stands studied tend to increase with increase in diameter; stem taper (tap^1) revealed a decrease as tree height increases while stem taper (tap^2) revealed an increase in stem taper as the tree height increases. Also, the study showed that tree height is a better function that can be used in estimating stem taper for *Triplochiton scleroxylon*.

RECOMMENDATION

The study however, recommended that, since the study made use of temporary sample plots, permanent sample plots be established within the various reserves for regular and consistent data collection and also to ensure continuity of provision of growth data for management purposes. In addition, more attention and security should be given to the few stands of *Triplochiton scleroxylon* species remaining in this reserve to ensure more researches are being done.

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